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each of the lines gives evidence of the phenomenon; i.e., if the residual fringes are oblique, each such line is strongly helical in appearance.

Hence the equation for the residual fringes may be assumed to be

$$n\lambda = (e-e')\,[\mu \cos(r-\alpha) - \cos i]$$

when e and e' are the thicknesses of the two half silver plates, μ their index of refraction, i the angle of incidence, r the angle of refraction of an incident ray, and where α is the outstanding angle between the faces of the differential glass wedge, $e-e'$ thick at the ray in question. The possibility of throwing these fringes into any order of size, their small extent, sharpness and great abundance of light constitute their value for measurement.

THE PROTEINS OF THE PEANUT, ARACHIS HYPOGAEA

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Communicated by R. Pearl, March 27, 1917

During the last ten years the culture of peanuts has increased rapidly in the United States. This increase is partly due to the fact that the boll weevil has made the growing of cotton unprofitable in various sections of the South and peanuts are now grown as a supplementary crop. Most of the peanuts thus produced are sold to the oil mills to be pressed for the oil which they contain. Shelled peanuts yield from 40 to 50% of oil. This edible oil compares favorably with olive oil and is used for culinary purposes and for making olemargarin. Press cake from shelled peanuts contains about 45% of protein (N x 6.25). This cake is ground to a meal which is rapidly finding favor as a cattle food. Peanut meal is now quoted at $35 per ton and peanut oil at $1.05 per gallon.

Previous to the present work, the only published experiments on the protein of the peanut seem to be those described by Ritthausen[2] in a paper which appeared in 1880. This author found that the proteins of the peanut consist chiefly of globulin and his analytical data led him to believe that only one globulin is present.

We have made fractional precipitations of the proteins extracted by sodium chloride solutions from oil-free peanut meal and have isolated two globulins, one of which is present only to a small extent. The globulin composing the greater part of the protein in the peanut is precipitated, when in 10% sodium chloride solution, by adding ammonium sulphate to 0.2 of saturation. To this globulin we have given the name *arachin*. After filtering off the arachin, the second globulin may be obtained by dialysis or by saturating the filtrate with ammonium sulfate. This second globulin we have named *conarachin.*

Isolation of Arachin.—An extract was made by mixing 500 grams of peanut meal with 2.5 liters of a 10% aqueous solution of sodium chloride. This mixture was then run through a mill and the resulting thin liquid was filtered clear through paper pulp. To the filtrate, solid ammonium sulphate was added gradually until the solution became 0.2 saturated with this salt. A precipitate began to appear at 0.15 of saturation and increased rapidly until 0.2 of saturation was reached, when precipitation practically ceased and did not occur again until much more ammonium sulfate was added. On allowing the 0.2 saturated solution to stand overnight, the precipitate settled in a very compact form so that the supernatant liquid could be easily decanted. The precipitate was washed with a 10% sodium chloride solution containing ammonium sulphate to 0.2 of saturation. The residue was then redissolved in a small volume of 10% sodium chloride, and the resulting solution was filtered and dialyzed until chlorides were removed. In this manner the greater part of the globulin present in the meal was obtained as a white powder. This was suspended in alcohol for twenty-four hours and in anhydrous ether for another twenty-four hours. It was then filtered off and freed from ether in a vacuum desiccator and finally dried to constant weight at 110°C.

Isolation of Conarachin.—The filtrate from which arachin had been removed, and which was now 0.2 saturated with ammonium sulphate, was completely saturated by adding more ammonium sulphate. This treatment produced a small quantity of precipitate. This was redissolved in 10% sodium chloride and the filtered solution dialyzed until free from chlorides. The conarachin was then dried in the same manner as the arachin.

Isolation of an Albumin.—Beside arachin and conarachin sodium chloride solutions also extract from peanut meal a trace of albumin which coagulates at 65 to 70°C. Carbon and hydrogen determinations made on a small quantity of this albumin gave results which agree closely with the values obtained by Osborne[3] and his co-workers for the legumelins frequently found in the seeds of leguminous plants.

The difference in the composition of arachin and conarachin is shown by the following analytical results:

	ARACHIN *Per cent*	CONARACHIN *Per cent*
C	52.15	51.17
H	6.93	6.87
N	18.29	18.29
S	0.40	1.09
O	22.23	22.58

It will be seen that the greatest difference between these two globulins is in the percentage of sulphur, which is nearly three times as great in conarachin as in arachin. Another marked difference between these two proteins is shown by the figures representing the distribution of nitrogen as determined by the Hausmann method. The figures are as follows:

N	ARACHIN	CONARACHIN
Amide	2.03	2.07
Humin	0.22	0.22
Basic	4.96	6.55
Non-basic	11.07	9.40
Total	18.28	18.24

The high percentage of basic nitrogen in these proteins is most striking and, as far as we know, conarachin contains more basic nitrogen than any other seed globulin yet examined. For the sake of comparison, the percentages of basic nitrogen in proteins from some seeds commonly used for foods are also given below.[4]

PROTEIN	SOURCE	BASIC NITROGEN *Per cent*
Zein	Maize	0.49
Gliadin	Rye	0.91
Gliadin	Wheat	1.09
Phaseolin	Kidney bean	3.62
Vicilin	Pea	4.92
Arachin	Peanut	4.96
Legumin	Pea	5.11
Excelsin	Brazil nut	5.76
Edestin	Hemp seed	5.97
Globulin	Cocoanut	6.06
Conarachin	Peanut	6.55

Percentage of Basic Amino Acids in the Globulins of the Peanut.—Arachin and conarachin were hydrolyzed by boiling with 20% hydrochloric acid for twenty-four hours. The hydrolyzates were then analyzed by the Van Slyke method. The following results are corrected for the solubilities of the phosphotungstates of the bases:

	ARACHIN *Per cent*	CONARACHIN *Per cent*
Arginine	13.51	14.60
Histidine	1.88	1.83
Lysine	4.98	6.04
Cystine	0.85	1.07

The figures for cystine are undoubtedly too low as they represent only the cystine which escaped destruction during the hydrolysis of the proteins. Both proteins also gave a strong qualitative test for tryptophane. For the sake of comparison the percentages of lysine in the proteins of some common seeds and in muscle from some animals are also given in the following tables:

Lysine content of some vegetable proteins

PROTEIN	SOURCE	PER CENT
Zein	Maize	0.00[5]
Gliadin	Wheat	*1.21[6]
Legumin	Pea	4.29[7]
Phaseolin	Kidney bean	4.58[8]
Arachin	Peanut	*4.98
Conarachin	Peanut	*6.04

Lysine in muscle substance of different animals[9]

Scallops (*Pecten irradians*)	5.77
Halibut (*Hippoglossus vulgaris*)	7.45
Chicken	7.24
Ox	7.59

The figures marked by an asterisk were obtained by the Van Slyke method and, therefore, probably represent the maximum percentage of lysine obtainable. Those not so marked were obtained by Kossel's absolute method and may be somewhat too low. It is seen, however, that the percentages of lysine in arachin and conarachin of the peanut are relatively high and, indeed, approach the lysine content of muscle substance of different animals. It will also be noted that no lysine has been found in zein and that the maximum percentage of lysine obtained from gliadin is only 1.21%.

Osborne and Mendel[10] and other workers have shown that lysine is essential to the growth of animals. Nutrition experiments indicate[11] that the animal organism cannot synthesize lysine which must, therefore, be provided in suitable quantity in the food to insure normal growth. Since the muscle substance of animals contains about seven per cent of lysine, foods deficient in this essential amino acid should be supplemented by the addition of other foods which contain a high percentage of lysine. Diets of wheat and corn, both of which contain but little lysine, should therefore prove more efficient if supplemented by some food of high lysine content. Peanut meal appears to be well adapted to this purpose. From a nutritive standpoint it is one of our cheapest foods and seems to possess no objectionable properties. Animals fed on it thrive well and increase rapidly in weight.[12] It, therefore, seems probable that corn and wheat could be much better utilized and a considerable saving in the cost of feeding effected by supplementing these cereals with peanut meal.

[1] This article is published by permission of the Secretary of Agriculture. A part of the work of which this is a summary appeared in *J. Biol. Chem.*, **28**, 1916, (77). The part relating to the determination of the basic amino acids in the proteins will appear in the May number of the same journal.

[2] Ritthausen, H., *Arch. ges. Physiol., Bonn*, **21**, 1880, (81).

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[4] Osborne, T. B., *The Vegetable Proteins*, London, 1909, p. 57.

[5] Osborne, T. B., and Jones, D. B., *Amer. J. Physiol., Boston*, **26**, 1910, (227).

[6] Osborne, T. B., Van Slyke, D. D., Leavenworth, C. S., and Vinograd, M., *J. Biol. Chem.*, **22**, 1915, (259).

[7] Osborne, T. B., and Clapp, S. H., *Ibid.*, **3**, 1907, (219).

[8] Osborne, T. B., *Ergebn. Physiol.*, **10**, 1910, (116).

[9] Osborne, T. B., and Jones, D. B., *Amer. J. Physiol., Boston*, **24**, 1909, (438).

[10] Osborne, T. B., and Mendel, L. B., *J. Biol. Chem.*, **22**, 1914, (325).

[11] Hopkins F. G., *London, J. Chem. Soc.*, **109**, 1916, (629).

[12] *U. S. Dept. Agric., Washington, Weekly News Letter*, **4**, No. 22, 1916.

A DESIGN-SEQUENCE FROM NEW MEXICO

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Much has been written on the development of geometrical decoration among primitive people, and many design-sequences have been arranged; the latter, however, have almost always been based on preconceived theoretical ideas, and the material for them has usually been selected from specimens whose relative ages have not been known. Such sequences cannot, therefore, be regarded as indicating surely the tendencies of design growth, for the specimens regarded as early may in fact have been late, and the development may thus have taken place in the opposite direction to the one postulated; or, again, the specimens may all have been of one period and may represent either contemporary variants of a single design-phase, or entirely unrelated parts of other unsuspected sequences. It has accordingly been impossible in most cases to do more than guess as to whether any given change in design has been from the natural to the conventional or vice versa; whether toward simplification or toward elaboration.

The only safe method for the working out of developments in decorative art is to build up one's sequences from chronologically sequent material, and so let one's theories form themselves from the sequences. In the case of aboriginal American art this ideal has been very hard to attain because of the scarcity of stratified sites and the corresponding difficulty of obtaining relatively datable specimens.

In the Rio Grande district of New Mexico, however, students have recently been recovering stratigraphical data which establish an orderly